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Proportional Mortality among Vinyl Chloride Workers*

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In a proportional mortality analysis of 161 deceased workers in two plants processing or producing vinyl chloride, a 50% excess of deaths due to all cancer was seen. Specific sites of cancer with the greatest excess included liver and biliary tract, lung and brain. The excess in fatal cancer was seen mainly in men who died before age 60. Also, there was a trend in time in the ratio of observed to expected deaths: since 1970 over twice as many cancer deaths as expected have occurred.

On February 15, 1974, four fatal cases of angiosarcoma of the liver which occurred among men who worked in a poly(vinyl chloride) polymerization plant were reported (*1*). In the present report a proportional mortality analysis of all deaths known to have occurred among workers in that plant is presented. Also included are deaths in men who worked in a plant in which vinyl chloride is produced.

Method

Vinyl chloride monomer is produced at a plant in Calvert City, Kentucky, and is polymerized into poly(vinyl chloride) at a plant in Louisville. These plants have been in operation since the late 1930's.

Whenever an active or pensioned employee at these plants dies, a copy of the death certificate is obtained. An abstract of the certificate is made and the certificate is sent to the insurance company. By using these sources, 161 deceased white males who employed at one of the two plants were identified. No information was available on workers who left employment prior to retirement. For all but 19 a copy of the death certificate was obtained. For the remainder, the cause of death as recorded in the company abstract was used. Deaths from 1947 through 1973 were ascertained. Of these deaths, 135 occurred among Louisville workers and 26 occurred among Calvert City workers.

The observed distribution of causes of death was tabulated using the code on the death certificate. The expected distribution was calculated on the basis of proportional mortality ratios for United States white males. The observed deaths from all causes were stratified into 5-yr age–time–specific groups, and age–time–cause–specific proportional mortality ratios were multiplied times these numbers to obtain the stratum-specific expected numbers (*2*).

Results

The patterns of mortality among workers in the two plants were similar, therefore all men were grouped together. As seen in Table 1, a 50% excess of deaths due to cancer was observed. ($\chi_1^2 = 5.7$, $p < 0.02$). In addition to the four deaths previously reported (*1*), a fifth man who died of angiosarcoma of the liver

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was identified. Also, there was one cancer of each of the following sites: gall bladder, common bile duct, and liver (type unspecified). There were five brain tumors, three of which were glioblastoma multiformae and two of which were of unspecified type. There was 60% excess of cancer of the lung, of the following cell types: bronchiogenic, 1; anaplastic, 1; adenocarcinoma, 3; unspecified, 8. There were two unusual other types of cancer: thyroid and nasopharynx.

There was an excess of deaths due to suicide: 10 observed and 5.3 expected.

The observed and expected numbers of all cancer according to age and year of death is presented in Table 2. Excess death due to cancer was seen primarily in men who died prior to age 60. There was a trend in the observed/expected ratio with year at death. Prior to 1965 no excess of deaths due to cancer was observed. However, since then there has been an increase in the proportion of death due to cancer, so that since January 1, 1970, death from cancer has occurred twice as frequently as would be expected on the basis of U.S. Vital Statistics data.

Table 1. Observed and expected deaths in vinyl chloride workers.[a]

ICD number[b]	Cause of death	Number of deaths		Ratio Obs/Exp
		Observed	Expected	
	All	161	161.0	1.0
140–205	All cancer	41	27.9	1.5
150–159	Digestive	13	8.3	1.6
155	Liver and biliary tract	8	0.7	11.0
162, 163	Lung	13	7.9	1.6
193	Brain	5	1.2	4.2
200–205	Lymphatic and hematopoietic	5	3.4	1.5
	Other[c]	5	7.1	0.7
330–334	CNS vascular	8	9.5	0.8
400–468	Circulatory	66	68.6	1.0
800–998	External	22	24.5	0.9
960–969	Suicide	10	5.3	1.9
	All other[d]	24	30.5	0.8

[a] Expected numbers based on age–time–cause–specific proportional mortality ratios for U.S. white males.
[b] International Classification of Diseases, 7th Revision.
[c] Nasopharynx, 1; prostate, 1; kidney, 1; thyroid, 1; undetermined, 1.
[d] Includes 2 cirrhosis (4.4 expected).

Table 2. Observed and expected deaths due to all cancer according to age and year of death.

	No. of deaths		Ratio Obs/Exp
	Observed	Expected	
Age at death			
<50	11	7.6	1.4
50–59	17	8.1	2.1
60+	13	12.2	1.1
Year of death			
<1965	12	11.4	1.1
1965–69	10	7.3	1.4
1970+	19	9.2	2.1

Discussion

These data include the original four vinyl chloride workers who were known to have died with angiosarcoma of the liver. Four other workers with fatal cancer of the liver and biliary system have been identified. In addition, there is a suggestion that at least two other types of cancer—lung and brain—appear with excess frequency in vinyl chloride workers. It also appears that the relative frequency of all cancers is increasing with time. While no projection into the future may be made with certainty, additional excess cancer among vinyl chloride workers would seem likely.

An analysis by use of proportional mortality ratios does not take into account the absolute risk of dying in the population being studied. Thus, it is possible that the overall mortality rate in the vinyl chloride workers is less than that of the United States population. For example, the overall mortality in white steelworkers was 86% of that expected (*3*) and in white cotton textile workers, 79% of that expected (*4*). However, even if each of the observed/expected ratios in Table 1 were multiplied by 0.8 (80%), an excess of cancer, especially of the liver and biliary tract and brain, would be present. Further, the increase with time in the ratio for all cancers would still be observed, since each of the observed/expected ratios in Table 2 would be multiplied by 0.8.

Another theoretical objection to a proportional mortality analysis is that a high ratio of observed to expected deaths may be due either to an excess of one cause of death or a deficit of another cause of death. Based on the data in

Table 1, it seems most likely that the high ratio for cancer reflects an excess of cancer, since the ratios for each of the four major categories other than cancer are all in the range of 80–100.

It will be several years before a final conclusion can be made with respect to the carcinogenic potential of vinyl chloride. Since any harmful effect in an individual may require many years of exposure, we believe that current exposure must be controlled.

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